AESTIVATION AND REPRODUCTIVE DORMANCY IN ADULT *HETERONYMPHA MEROPE MEROPE* (FABRICIUS) (LEPIDOPTERA:NYMPHALIDAE)

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Abstract

Field and laboratory data are presented on aestivation and reproductive dormancy of adult *Heteronympha merope merope* (Fabricius) in New South Wales. Females emerge in October-November then aestivate, and ovarian development does not occur until early January. Ovarian maturation occurs primarily in response to cool temperatures and is enhanced by short photoperiods. Field populations become gravid from mid-February to mid-April depending upon local temperatures. Reproductive maturation is accompanied by an abrupt change in behaviour from sheltering and inactivity, to flight and dispersal.

Introduction

Heteronympha merope merope (Fabricius), the common brown butterfly, is widespread in southeastern Australia occurring in a wide range of habitats from metropolitan gardens to mountain forests (Common and Waterhouse 1981). In many years populations are extremely large, particularly in coastal areas and on the tablelands. In New South Wales adults first appear in October or November with males exhibiting marked protandry (Edwards 1973). Edwards (1973) suggested that females aestivate and showed that although mating occurred soon after emergence in spring, ovarian development did not occur until autumn. Males usually die by mid-summer resulting in autumn populations of only females.

This paper provides additional field and laboratory data on aestivation and reproductive dormancy of *H. m. merope.*

Materials and Methods

To investigate the nature of summer reproductive dormancy in *H. m. merope* and the factors involved in its termination, females were obtained from November 1985 to March 1986 at a 0.25 ha site at Hazelbrook in the Blue Mountains, 95 km west of Sydney, New South Wales. The butterflies sampled were inactive individuals and considered to be part of an aestivating population which was confined to woodland. Samples of 5-40 females were transferred to the laboratory and exposed to warm (30°C) or cool (20°C) temperatures under long day (LD 15:9 h) or short day (LD 10:14 h) photoperiods, or dissected for examination of the reproductive system. Experimental butterflies were held in wire-framed, muslin covered cages in

constant enviroment chambers with a maximum temperature variance of ± 1°C. They were provided with a sugar solution daily and maintained for 10-30 days after which they were dissected, examined for ovarian development and whether inseminated. Females were considered to have developing ovaries if immature (unchorionated) or mature (chorionated) oocytes were present in the ovarioles. Inseminated females were identified by the presence of a spermatophore in the bursa copulatrix. Butterflies were dissected shortly after capture to provide data on the reproductive status of females during the sampling period. Additional autumn samples of *H. m. merope* were obtained from Leeton, 490 km west-south-west of Sydney in 1986 and 1987. Individuals collected in Leeton in March 1986 and February 1987 were from an aestivating population.

Twenty females reared in the laboratory at 22 ± 2°C, LD 15:9 h since collection as 3rd instar larvae at Hazelbrook in late July 1985, were used in an attempt to affect reproductive dormancy. After eclosion in September they were exposed to 28 ± 1°C and LD 15:9 h for 24 days. Five females were then transferred to 21 ± 2°C and LD 12:12 h for 24 days. Ovaries were examined prior to the experiment (after eclosion), at the end of the initial 24 day period and at the conclusion of the experiment.

Results

Data on the ovarian condition and insemination of females at Hazelbrook are presented in Table 1. Mated females predominated throughout although ovarian development was not detected until mid-February when mean daily temperature fell below 20°C and daylength was around 13.3 h. In 1986 females collected early in March at Leeton, when the mean daily temperature was 25.5°C and daylength was 12.7 h, showed no ovarian development (Table 1). Mean daily temperature in this area did not consistently fall below 20°C until early April. All females sampled from Leeton in mid-April 1986 were gravid. In 1987 temperatures at Leeton dropped below 20°C in late February. Ovarian development was detected in early March.

Termination of ovarian dormancy in both years was associated with a period of noticeable change in female behaviour. Prior to reproductive development females remained largely inactive. Cool, shady resting places were sought and the butterflies only flew when disturbed. At Hazelbrook they remained inactive within woodland but after mid-February were commonly found flying in gardens, parks and along roadsides. At Leeton aestivating females were found from February-March (1986) and from December-February (1987) in forest areas along the Murrumbidgee River, with aggregations of up to 50 individuals sheltering in dark locations such as under fallen trees and in animal burrows. Once reproductive development commenced, females appeared in town areas and became common throughout the district.

Table 1: Ovarian development and insemination of female *H. m. merope* collected at Hazelbrook from November 1985 to March 1986, and at Leeton during February, March and April in 1986 and 1987.

Sample date	n	No. insem-inated	No. females with ovarian development	Mean No. mature oocytes	Day length (h)	Mean daily temp. (°C) (previous 7 d)
HAZELBROOK						
1.xi.85	20	13	0	0	14.3	23 ± 2.3
1.xii	10	7	0	0	14.6	24.8 ± 3.6
29.xii	5	4	0	0	14.7	25.7 ± 1.2
6.i.86	5	5	0	0	14.7	26.2 ± 2.6
17.i	5	4	0	0	14.2	24.8 ± 1.9
24.i	5	5	0	0	13.9	22.8 ± 1.8
2.ii	5	3	0	0	13.7	23.7 ± 2.4
9.ii	5	5	0	0	13.5	21.4 ± 1.3
15.ii	5	5	4	42.8	13.3	19.7 ± 2.1
22.ii	5	5	4	20.6	13.1	19.8 ± 1.2
1.iii	5	5	5	25.2	12.8	17.6 ± 2.1
9.iii	5	5	5	53.4	12.5	19.7 ± 1.6
20.iii	5	5	5	56	12.2	19.1 ± 2.1
LEETON 1986						
5.iii	5	5	0	0	12.7	25.5 ± 2.1
11.iv	5	5	5	72.6	11.6	17.0 ± 3.1
LEETON 1987						
20.ii	5	5	0	0	13.2	25.4 ± 2.1
3.iii	5	5	4	12.3	12.7	18.5 ± 2.1

The effect of temperature and photoperiod on ovarian development in *H. m. merope* during summer and autumn is shown in Table 2. No females obtained before January showed any reproductive development regardless of treatment. Individuals collected in November, December and early January failed to survive more than 7 days at 30°C. Females taken in early January and held at 20°C for 30 days showed ovarian development, although only short photophases promoted a 100% sample response. The apparent greater stimulatory effect of short photophase was repeated in late January when only individuals exposed to short days at 20°C showed ovarian development after 10 days (Table 2). After 16 days, 40% of females held under long days at the same temperature also demonstrated reproductive development. Females obtained in early February also showed enhanced ovarian development at a short photophase. All females collected during January and February and exposed to 30°C conditions failed to develop reproductively.

In an experiment designed to stimulate ovarian development in newly-emerged females containing undeveloped ovaries (n=5), exposure to warm (28°C) temperatures and long (15 h) photophases for 24 days did not result in observable ovarian development (n=5). All individuals held for the next 24 days at 21°C and a 12 h photophase commenced ovarian development (mean number of mature oocytes = 58.5 $\pm$ 16.8 n=5). Butterflies kept at 28°C, LD 15:9 for the entire period remained non-reproductive (n=5).

Discussion

The data presented here confirm the occurrence of aestivation and reproductive dormancy in female *H. m. merope* in New South Wales. Prior to this study the nature of reproductive dormancy shown by *H. m. merope* females in summer was not understood. The current data indicate that aestivating females did not commence ovarian development until early January, even if presented with suitable temperatures, photoperiods and food. This behaviour is characteristic of the refractory phase of reproductive diapause in which insects do not respond to normally favourable enviromental stimuli (Lees 1955, Tauber and Tauber 1976). In the laboratory exposure to 24 days at 28°C, LD 15:9 was sufficient to "prime" newly emerged females for ovarian development in subsequent cool, short day conditions. No such delay in reproductive development occurs in males which are sexually active throughout their lives (Edwards 1973, Common and Waterhouse 1981). Confirmation of the presence of reproductive diapause in aestivating females of *H. m. merope* must await studies on the endocrine system. However, it is apparent that reproductive dormancy in *H. m. merope* is not a simple and flexible direct response to unfavourable conditions as is the case with the Australian race of *Danaus plexippus* L. (James 1982). Although further studies are required it seems likely

Table 2: Ovarian development in wild *H. m. merope* females collected at Hazelbrook (November 1985 - February 1986) and exposed to 20°C or 30°C and LD 15: 9 h or LD 10: 14 h. Numbers represent mean numbers of mature oocytes per sample. The percentage of each sample with ovarian development is shown in parentheses. Lower figure in parentheses shows sample size.

Date of Sample	Holding Period (days)	Holding Temperature and Photoperiod 20°C LD 10:14	20°C LD 15:9	30°C LD 10:14	30°C LD 15:9
7.xi.85	21	0 (8)	0 (10)	0 (5)	0 (7)
29.xii	21	0 (10)	0 (12)	0 (8)	0 (9)
6.i.86	30	60 (100%) (10)	55(60%) (10)	0 (10)	0 (10)
26.i	10	11(60%) (10)	0 (10)	0 (10)	0 (10)
26.i	16	36(100%) (8)	10(40%) (10)	0 (10)	0 (10)
8.ii	10	62(100%) (10)	45(60%) (10)	0 (10)	0 (10)

that adult reproductive dormancy in *H. m. merope* is obligatory. Rearing of larvae under various temperatures and photoperiods failed to produce any females showing continuous development (James unpublished observations). Summer diapause is similar to winter diapause but usually has a converse relationship with photoperiod and temperature. Long photoperiod and high temperatures tend to induce and/or maintain summer diapause, whereas short photoperiod and low temperature prevent and/or terminate it (Masaki 1980). Commencement of ovarian development in *H. m. merope* appears to be controlled by a combination of cool temperature and short photoperiod, with temperature perhaps exerting the greatest influence. In the field ovarian development occurred only when mean daily temperature was less than 20°C. Thus, in 1986 gravid females occurred at Hazelbrook in mid-February but did not appear until much later in Leeton where warm conditions persisted longer.

Observations made during this study confirmed the aestival behaviour of *H. m. merope* first reported by Edwards (1973). From November to February or March females remained largely inactive in cool, shady habitats

which offered at least some respite from summer heat. Aestivating females contain large amounts of fat (James unpublished data) and do not feed (Edwards 1973).

The physiology of female *H. m. merope* in summer ensures that oviposition is probably delayed to a time most suitable for development of the hatching larvae. Over much of southeastern Australia larval host plants, soft grasses die back during summer and recommence growth during autumn. In the Leeton area, for instance, virtually no suitable host plants occur during summer, while autumn and winter are characterised by often luxuriant pasture growth. Larval development occurs during late autumn, winter and spring and preliminary evidence indicates the presence of another diapause during this stage (James unpublished observations).

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